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Climatic Factors Affecting Quantity and Quality Grade of *in vivo* Produced Bovine Embryos

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Summary and Implications

The present study investigated the effects of climatic variables on the quality grade and quantity of *in vivo* produced bovine embryos.

High temperature during the early embryonic development stage, one day after AI to flush, tended ($P < 0.10$) to decrease the quality of embryos recovered. High Temperature-Humidity Index during the early antral follicular stage, 40 to 45 days prior to ovulation, tended to improve the total number of freezable and transferrable embryos recovered per flush ($P < 0.10$). Increased wind speed at the early antral follicular phase was associated with a significant increase of the percentage of quality grade 1 embryos recovered ($P < 0.05$). This implies that wind has a significant effect in the quality grade and quantity of in vivo produced bovine embryos that is rarely taken into consideration.

Introduction

One of the primary factors decreasing the effectiveness of superovulation is the decreased fertility associated with heat stress. *In vivo* production of bovine embryos shows a noticeable decline in both embryo recovery rate and quality grade during the warmer months of the year.

Heat stress constitutes an important challenge for grazing cattle in the Midwest of the United States. The negative effect of heat stress on reproductive performance can be intensified by the negative impacts of endophyte-infected tall-fescue grass, which contains alkaloids like ergovaline. Ergovaline causes vasoconstriction in cattle, impairing the ability to dissipate heat through dilation of subcutaneous blood vessels. Because of this, cattle that feed on endophyte-infected tall fescue have elevated core body temperatures and respiration rates.

Materials and Methods

This study used 1,420 records of superovulatory embryo flushes performed by the Iowa State University (ISU) College of Veterinary Medicine collected from March, 2000 to December, 2016. The donors represented 20 different breeds plus some crossbreds. The breeds included were Ayrshire, Santa Gertrudis, Charolais, Chianina, Dexter, Shorthorn, Gelbvieh, Milking Shorthorn, Jersey, Red Angus, Black Angus, Simmental, Limousine, Maine Anjou, Senepol, Simmental/Angus Cross, Polled Hereford, Horned Hereford, Club Cattle, and crosses of unknown breeds that were grouped together. The climatic data used in this study were obtained from the Iowa Environmental Mesonet (IEM) Website using the ISU AgClimate database and the ISU Soil Moisture.

The response variables included the number of structures, viable embryos, quality grade 1 embryos, quality grade 2 embryos, quality grade 3 embryos, freezable embryos (sum of quality grade 1 and quality grade 2 embryos), transferrable embryos (sum of quality grade 1, 2, and 3 embryos), degenerate embryos, and unfertilized ova

All the variables were analyzed as average number obtained per flush and as a proportion of recovered structures within a flush. The time points analyzed were: one day after AI to flush, 4 days prior to AI up to and including AI date, 4 days prior to and including the day of initiation of synchronization/superovulation protocol, referred as synchronization date, 40 to 45 days prior to ovulation, referred to as early antral follicle phase, and 80 to 85 days prior to ovulation, referred to as the period of activation of primordial follicles.

Results and Discussion

Wind speed during the 40-45 day period before AI showed a significant positive effect on the quality grade 1 embryos. Higher wind speed during estrous synchronization significantly affected the number and percentage of degraded and unfertilized ova, referred to as discardable-quality embryos. A rise of 1km/h in the wind speed caused a reduction of 0.16 ± 0.07 discarded embryos per flush. Also, at this stage an increase of 1km/h on wind speed caused a decrease of 0.02 ± 0.008 quality grade 3 embryos recovered per flush.

This study confirms that climatic variables have significant effects on the *in vivo* production of bovine embryos and that the cooling effect of wind speed should be considered when scheduling the *In vivo* production of bovine embryos.

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Table 1. Mean monthly weather parameters averages from 2000 to 2016.

Month	**High T (ºC)**[1]	**Low T (ºC)**[2]	**Mean T (ºC)**[3]	**RH (%)**[4]	**Wind (km/h)**[5]	**THI**[6]
January	-1.64	-11.22	-6.43	81.42	8.57	24.3
February	0.18	-9.8	-4.81	81.18	8.68	26.96
March	8.09	-2.67	2.71	75.24	8.68	39.77
April	16.26	3.8	10.03	65.92	9.48	51.54
May	21.89	10.09	15.99	67.88	8.32	60.27
June	26.92	15.69	21.31	72.61	6.46	68.46
July	28.65	17.59	23.12	79.34	5.03	71.81
August	27.65	16.44	22.05	81.74	4.85	70.29
September	24.34	11.53	17.93	73.98	5.83	63.36
October	16.59	4.58	10.58	71.98	7.02	52.12
November	8.96	-1.95	3.5	76.36	8.23	40.88
December	0.02	-8.94	-4.46	84.31	8.42	26.93

[1]High T (ºC): average daily highest temperature in degrees Celsius.

[2]Low T (ºC): average daily lowest temperature in degrees Celsius.

[3]Mean T (ºC): mean daily temperature in degrees Celsius.

[4]RH(%): average daily relative humidity.

[5]Wind (km/h): daily average wind speed in km/h.

[6]THI: Temperature-humidity index.

Table 2. Regression coefficients and SE of weather variables on number and percentage of embryos according to quality grade.

Effect	Q1 recovered per flush[1], n	Q1 Transferrable[2], %	Q1 Freezable[3], %	Q2 recovered per flush[4], n	Q2 Transferrable[5], %	Q2 Freezable[6], %	Q3 recovered per flush[7], n	Q3 transferrable [8], %
high T 80s (ºC)[a]	0.02 ± 0.14	-0.02 ± 0.01	-0.02 ± 0.01	-0.004 ± 0.05	0.0003 ± 0.009	-0.001 ± 0.010	0.01 ± 0.02	-0.002 ± 0.004
high T 40s (ºC)[b]	-0.33 ± 0.15**	-0.02 ± 0.01	0.02 ± 0.02	0.003 ± 0.06	-0.003 ± 0.01	-0.002 ± 0.01	-0.01 ± 0.02	0.0006 ± 0.004
high T Sync (ºC)[c]	0.03 ± 0.13	0.003 ± 0.01	0.002 ± 0.01	-0.07 ± 0.05	-0.006 ± 0.008	-0.01 ± 0.009	-0.02 ± 0.02	-0.003 ± 0.003
high T AI (ºC)[d]	-0.16 ± 0.13	-0.0004 ± 0.01	-0.00001 ± 0.01	-0.02 ± 0.05	-0.001 ± 0.009	0.0003 ± 0.009	0.01 ± 0.02	0.004 ± 0.003
high T Flush (ºC)[e]	0.23 ± 0.16	-0.006 ± 0.01	-0.006 ± 0.02	-0.003 ± 0.06	-0.02 ± 0.01	-0.02 ± 0.01*	-0.02 ± 0.03	-0.005 ± 0.004
wind speed 80s (km/h)[f]	0.004 ± 0.05	0.001 ± 0.0052	0.0002 ± 0.005	-0.003 ± 0.02	-0.002 ± 0.003	-0.003 ± 0.004	-0.02 ± 0.008**	-0.002 ± 0.001
wind speed 40s (km/h)[g]	0.0004 ± 0.06	0.014 ± 0.006**	0.014 ± 0.006**	0.007 ± 0.02	0.0009 ± 0.004	0.001 ± 0.004	-0.005 ± 0.01	-0.0006 ± 0.002
wind speed Syncs(km/h)[h]	-0.004 ± 0.06	-0.010 ± 0.006	-0.01 ± 0.006	-0.04 ± 0.02	0.004 ± 0.004	0.004 ± 0.004	-0.003 ± 0.009	-0.0002 ± 0.002
wind speed AI (km/h)[i]	0.06 ± 0.06	0.005 ± 0.006	0.007 ± 0.006	0.01 ± 0.02	-0.003 ± 0.004	-0.003 ± 0.004	0.006 ± 0.009	0.0009 ± 0.002
wind speed Flush (km/h)[j]	-0.022 ± 0.07	-0.009 ± 0.007	-0.009 ± 0.006	-0.02 ± 0.02	-0.004 ± 0.004	-0.003 ± 0.005	0.01 ± 0.01	0.002 ± 0.002
THI 80s[k]	-0.034 ± 0.10	0.01 ± 0.009	0.01 ± 0.009	-0.008 ± 0.03	-0.002 ± 0.006	-0.001 ± 0.006	-0.01 ± 0.01	0.0007 ± 0.002
THI 40s[l]	0.22 ± 0.10**	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.04	0.004 ± 0.007	0.003 ± 0.007	0.006 ± 0.02	-0.0004 ± 0.003
THI Syncs[m]	0.02 ± 0.09	-0.002 ± 0.008	-0.001 ± 0.009	0.04 ± 0.03	0.004 ± 0.005	0.007 ± 0.006	0.01 ± 0.01	0.002 ± 0.002
THI AI[n]	0.13 ± 0.09	0.0003 ± 0.009	0.008 ± 0.009	0.01 ± 0.03	0.002 ± 0.006	0.0003 ± 0.006	-0.008 ± 0.01	-0.002 ± 0.002
THI Flush[o]	-0.22 ± 0.11*	0.003 ± 0.01	-0.003 ± 0.01	-0.006 ± 0.04	0.008 ± 0.007	0.01 ± 0.007	0.01 ± 0.02	0.003±0.003

* represents 0.1≥P>0.05

**represents 0.05≥P>0.01

[1]Number of quality grade 1 embryos recovered per flush.

[2]Quality grade 1 embryos recovered per flush as a percentage of transferrable embryos (quality grade 1, 2 and 3).

[3]Quality grade 1 embryos recovered per flush as a percentage of freezable embryos (quality grade 1 and 2).

[4] Number of quality grade 2 embryos recovered per flush.

[5] Quality grade 2 embryos recovered per flush as a percentage of transferrable embryos (quality grade 1, 2 and 3).

[6]Quality grade 2 embryos recovered per flush as a percentage of freezable embryos (quality grade 1 and 2).

[7] Number of quality grade 3 embryos recovered per flush.

[8] Quality grade 3 embryos recovered per flush as a percentage of transferrable embryos (quality grade 1, 2 and 3).

[a]High T 80s(ºC): average daily highest temperature in degrees Celsius 80-85 days prior to ovulation.

[b]High T 40s(ºC): average daily highest temperature in degrees Celsius 40-45 days prior to ovulation.

[c]High T Sync(ºC): average daily highest temperature in degrees Celsius 4 days prior to and including synchronization date.

[d]High T AI (ºC): average daily highest temperature in degrees Celsius 4 days prior to AI up to and including AI date.

[e]High T Flush(ºC): average daily highest temperature in degrees Celsius one day after AI up to flush date.

[f]Wind speed 80s (km/h): daily average wind speed in km/h 80-85 days prior to ovulation.

[g]Wind speed 40s (km/h): daily average wind speed in km/h 40-45 days prior to ovulation.

[h]Wind speed Synchss (km/h): daily average wind speed in km/h 4 days prior to and including synchronization date.

[i]Wind speed AI (km/h): daily average wind speed in km/h 4 days prior to AI up to and including AI date.

[j]Wind speed Flush (km/h): daily average wind speed in km/h one day after AI up to flush date.

[k]THI 80s: Average Temperature-Humidity Index 80-85 days prior to ovulation.

[l]THI 40s: :Average Temperature-Humidity Index 40-45 days prior to ovulation.

[m]THI Sync: Temperature-Humidity Index 4 days prior to and including synchronization date.

[n]THI AI: Temperature-Humidity Index 4 days prior to AI up to and including AI date.

[o]THI Flush: Temperature-Humidity Index one day after AI up to flush date.